

Instability Analysis of a Flexible Channel Using Numerical Methods

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Contributions from:

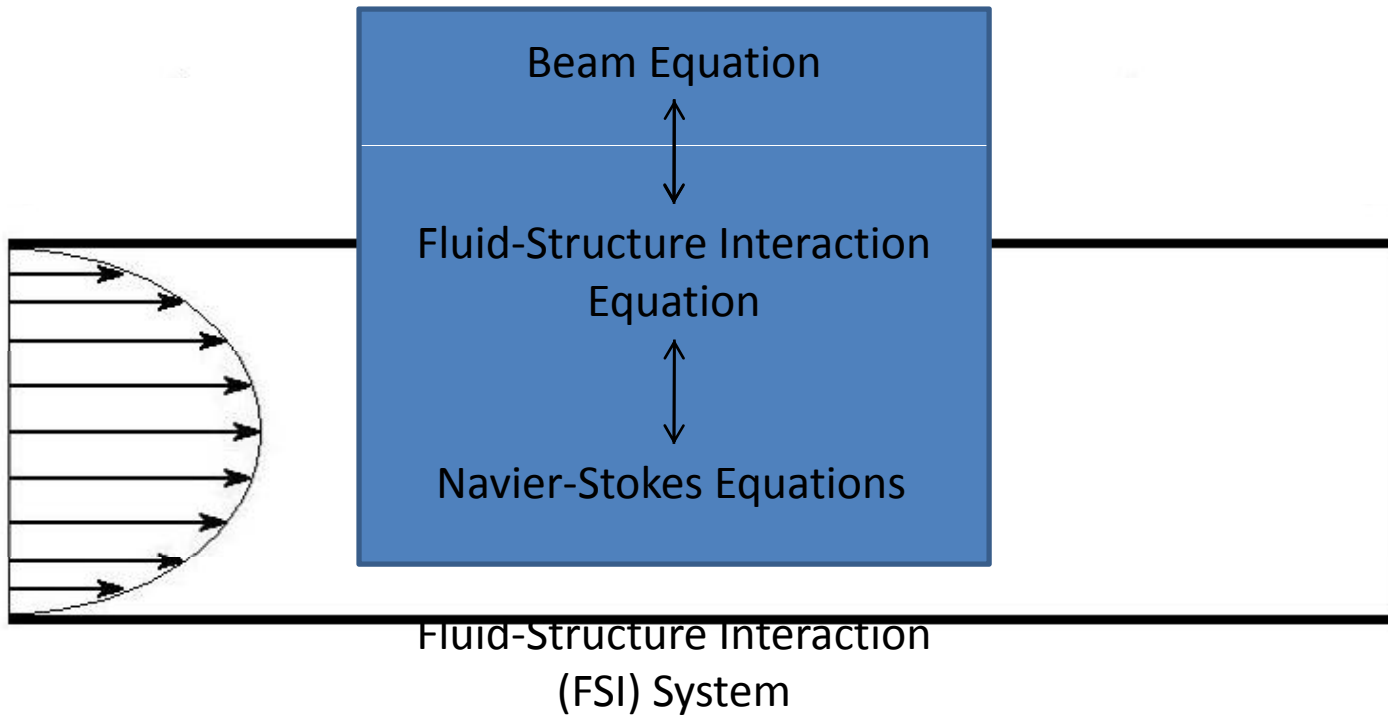
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Presentation Outline

- Case Study Model
- Fluid-Structure Interaction (FSI) program - oomph-lib
- Results
- Applications
- Future work

Case Study Model

2-dimensional channel with a flexible section hinged at both ends



Dimensional Test Parameters

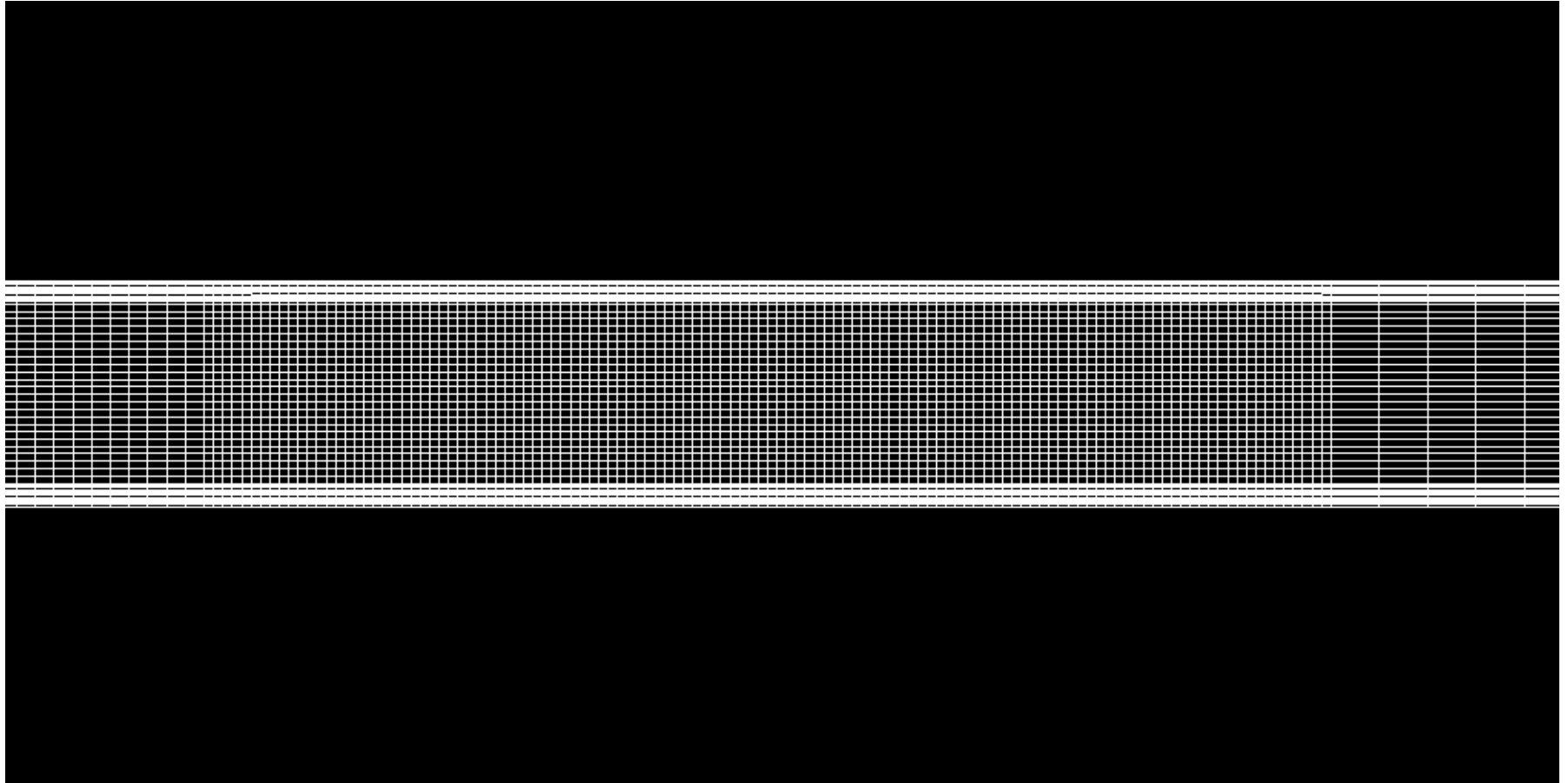
Parameter	Value	Description
L_{up}^*	5×10^{-2} m	Upstream length of channel
$L_{collapsible}^*$	5×10^{-2} m	Collapsible length of channel
L_{down}^*	30×10^{-2} m	Downstream length of channel
H^*	1×10^{-2} m	Height of channel
h^*	1.095×10^{-4} m	Thickness of flexible wall
ρ_f^*	1×10^3 kg.m ⁻³	Density of fluid
μ^*	1×10^{-3} Pa.s ⁻¹	Dynamic viscosity of fluid
ν	0.5	Poisson's ratio of solid
$\rho_s^* h^*$	0 kg/m ²	Mass per unit area of solid
B^*	7.2×10^{-9} N.m	Flexural rigidity of flexible wall
U_{mean}^*	0.030 m/s (Re 30) 0.035 m/s (Re 35)	Inlet mean velocity

Fluid-Structure Interaction (FSI) Program

the object-oriented multi-physics finite-element library

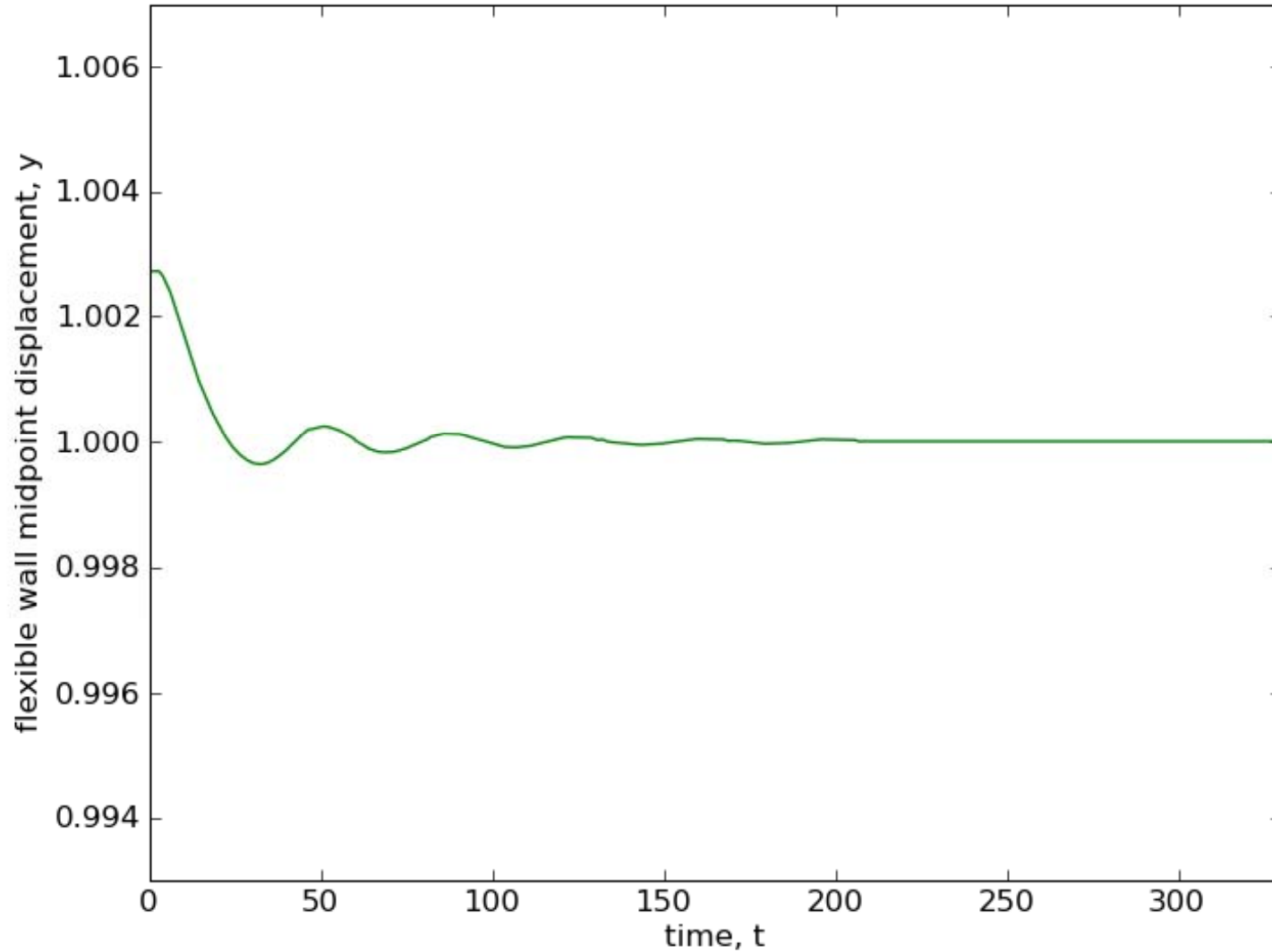
- Element modelling equations
 - Solid: Kirchoff-Love equation (Beam Elements)
 - Fluid: Navier-Stokes equations (Taylor-Hood Elements)
- Easy to combine element types to create "multi-physics" elements, allowing
 - the solution of fluid-structure interaction problems
 - Fully-coupled, solved using Finite Element Analysis (FEA)
 - the simulation of heat transfer
 - free-surface problems
- Open source software – Free (GNU Public Licence)

Mesh

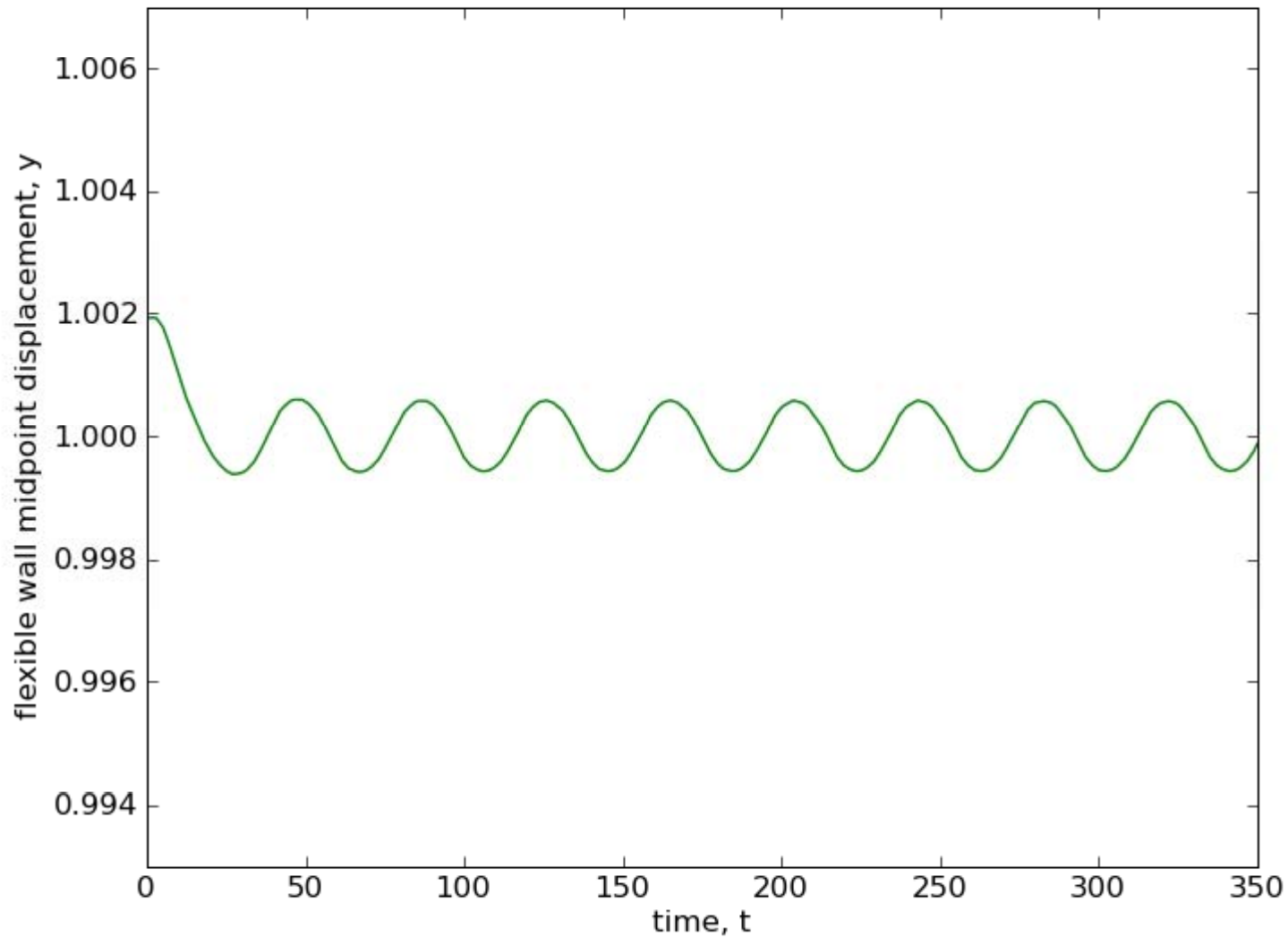


Results

Re 33 Flexible Wall Midpoint Displacement vs Time



Re 35 Flexible Wall Midpoint Displacement vs Time



Data Representation

- Channel Pressure Distribution
- Pressure Perturbations
- Channel Velocity Distribution
- Velocity Perturbations
- Velocity Profile

Applications

- Study of strong-coupling FSI problems
- Oomph-lib advantage over ANSYS (monolithic vs. partitioned solver)
- Applications of strong-coupling FSI problems
 - Biomechanics (Upper airway modelling)
 - Drag reduction/boundary layer control using compliant membranes
 - Hull design
 - Subsea compliant surfaces

Future Work

- 2 flexible walls
- Turbulence models
- Test parameters for subsea conditions for subsea applications
- Introduction of external fluid (outside of channel) to model underwater current behaviour.

End